"JOURNAL OF THE CONSTRUCTORS CLUB"

Hot Iron

Autumn 2014 Issue 85

Editorial

Following on from Peter Cochrane's remarks about where amateur radio could head, the Chairman of the RSGB Board Graham Murchie GG4FSG has discussed how to get more (and younger) people into amateur radio and actively participating. He devoted two pages to the topic in the Aug 2014 Radcom to promote discussion and get people to send in ideas, which I did! I gather that I am not alone in suggesting encouragement of the building of radio projects. As ever, for youngsters and newcomers, price and convenience are the dominant factors. Hence my suggestion that the use of double sideband (with suppressed carrier) is the cheapest way to get on the air with voice, and a simple rig based on a SA602 mixer can be made to work both on reception and transmission. The Wick does exactly that and is consequently about the lowest cost method of getting on air. Using a ceramic resonator for the control of frequency (on 80 or 160m) provides a fair tuning range too, with little chance of straying outside the band!

Newcomers have little chance of making VHF gear work, whereas the MF bands are pretty straightforward. The main problem for these lower bands, is the size of normal aerials - but all is not lost! Magnetic loops can be made very effective and also quite simply constructed. So provided you don't expect to work DX, a simple low power rig plus loop is highly suitable for group projects where either across site, or across town contacts are desired/possible. I suggested that the RSGB should try to persuade Ofcom to allow fixed frequency very low power transmission under the control of suitably qualified teachers but I am told this is a no-no! By way of an example of what can be achieved, the photo below shows a demo set up that I made for the Yeovil QRP Convention this year; it is a COMPLETE 80m phone station – including rig, battery and loop aerial. I suggest that an RSGB badged project along these lines could go a long way to helping bring fresh people to the hobby! Tim G3PCJ

Contents Kit Developments, The High Ham, Roaring Mick update, MOSFETs & biasing, Wall warts, Supplies for 12v gear, RF Power measurement, Storage Batteries, Ring of Three amp, Nested Loop antennas.

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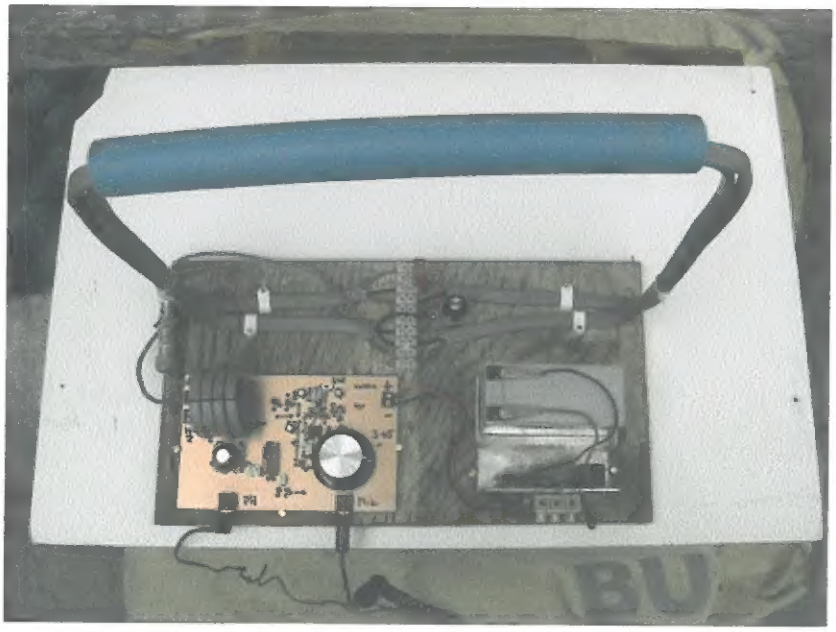
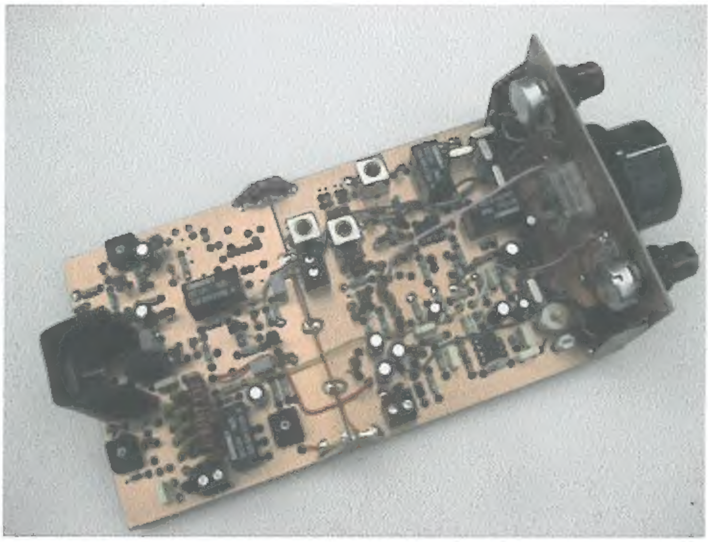


Kit Developments



Initial reports on the performance of the Marsh are encouraging. It and the Mells, which turns the Marsh into a three band full break-in CW TCVR, are available now.

I do now also have working the prototype Rode RX and its associated 5W Rudge TX. These are the SSB phone pair intended for Buildathon projects. See right. They use a simpler IF filter at 10 MHz and can do any single band of the 20, 40 and 80m group. Their novel aspect – relay switching of the RX IF strip for transmission – is working well. I am expecting Steve Hartley to be making one shortly.

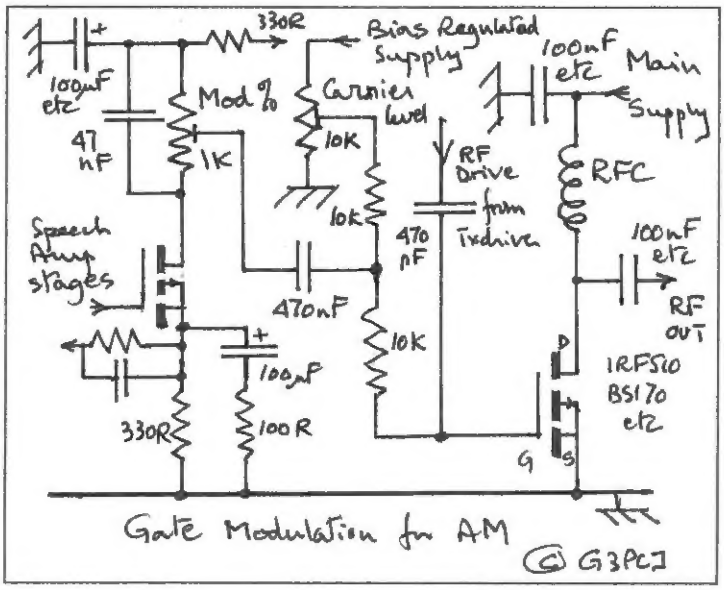
The High Ham

I have also laid out, but not yet built, the High Ham; it is a small TX and AM modulator. It is a bit of an experimenters kit! It has the digital oscillator, broadly as described in the last Hot Iron, with the ability to run with a ceramic resonator on its fundamental; or with a crystal on its overtone frequencies. In the desire to get onto 6m without a lot of hassle I have long been trying to avoid higher harmonics and so looked for a crystal that would get to 6m on its third harmonic. Luckily there is a 'standard' low cost one at 16777.2 KHz which gets us to 50.33 MHz; this will be much easier than using the fifth harmonic of 10.106 etc. I have ordered up a few of these crystals for experiments. For the output stage, which is digitally driven by three gates in parallel, I have given it the option of either an IRF510 with 1:2 transformer and potentially 5W out for the low bands, or a pair of BS170s for 1.5W on the higher bands to 6m.

The Cheltenham Club have expressed an interest in an Amplitude Modulated TX kit for a group project and so I have added that capability to the High Ham. The speech modulator is primarily a conventional pair of BS170s arranged as a feedback pair for biasing purposes; but to make the output levels into volts peak to peak of audio, I turned the normal source follower output stage into a common source amplifier with a gain of about 10. This is just the job for gate modulation of the output stage instead of the conventional AM arrangement of modulating the supply voltage. The very nature of AM requires the TX to run at one quarter of its peak RF output with no audio, or plain carrier; hence there is a fair dissipation all the time and the normal need for a watty modulator to drive the RF stage supply between 0 volts and twice the supply volts on audio peaks at full modulation.

Instead, with MOSFET RF output stages, you can apply the modulation to their gate with almost the same results. But because the gate is a high impedance spot, there is very little power required from the modulator, merely a few volts peak to peak to make the RF output go between zero and twice the carrier voltage level (and hence 4 times the power) as desired. This avoids power hungry modulators and audio transformers, which are like hens teeth nowadays!

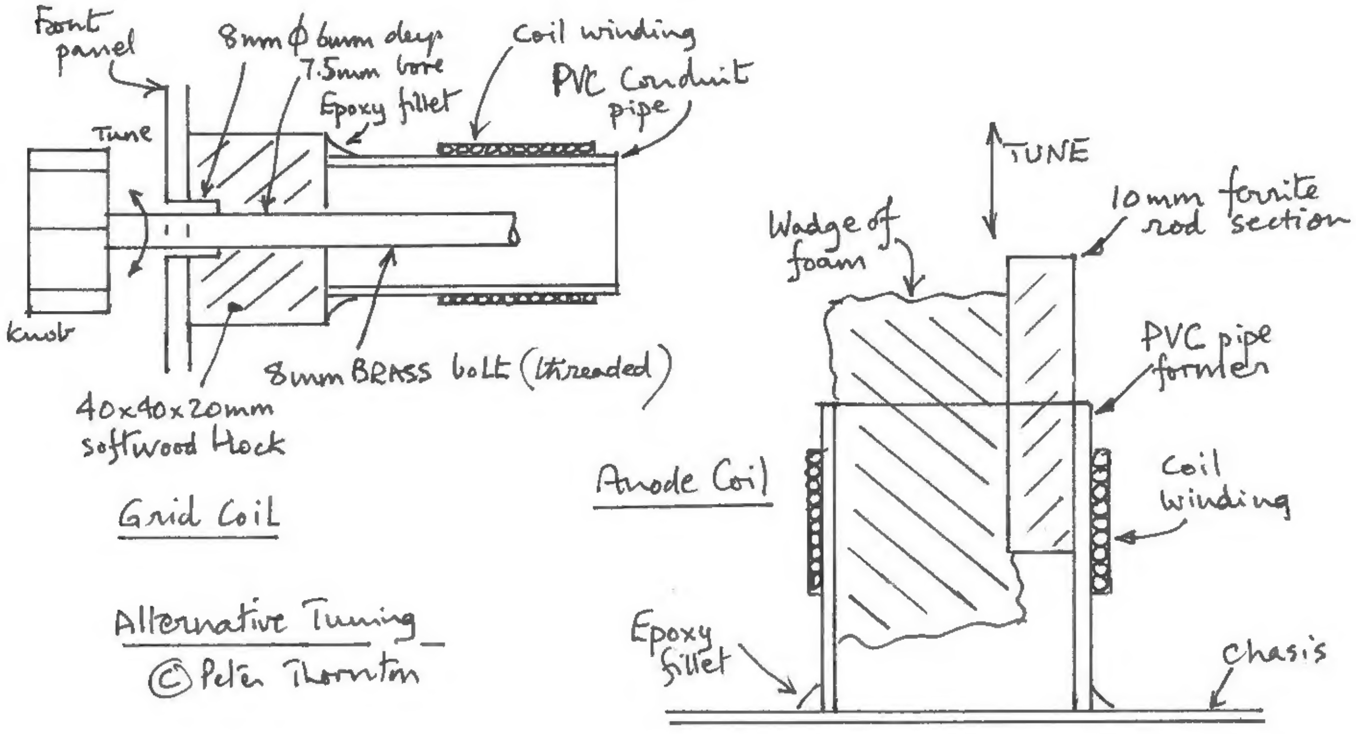
The Mark regen RX, which can demodulate AM, is the most suitable RX to go with the High Ham. G3PCJ



Roaring Mick Update - How to eliminate the variable capacitors – by Peter Thornton

The resonant frequency of a tuned circuit is given by the square root of inductance divided by capacitance; therefore if I eliminate varying the capacitance, the inductance is the only variable that can alter the resonant frequency. Historically, permeability tuning was much in favour being easier and cheaper than creating multi-section variable capacitors that tracked accurately. The manufacturers used iron / ferrite slugs to *increase* the inductance, with brass threaded inserts to *reduce* the inductance – thus each section of a multi-section tuner could be adjusted and trimmed to track exactly. I adopted the same principle with Mick: the half frequency grid coil had more turns than required, and an 8mm brass bolt effectively cancels turns to bring the inductance down. The anode coil uses a ferrite rod section, held in place by a foam plastic pad, to increase the inductance, thus tuning the anode circuit.

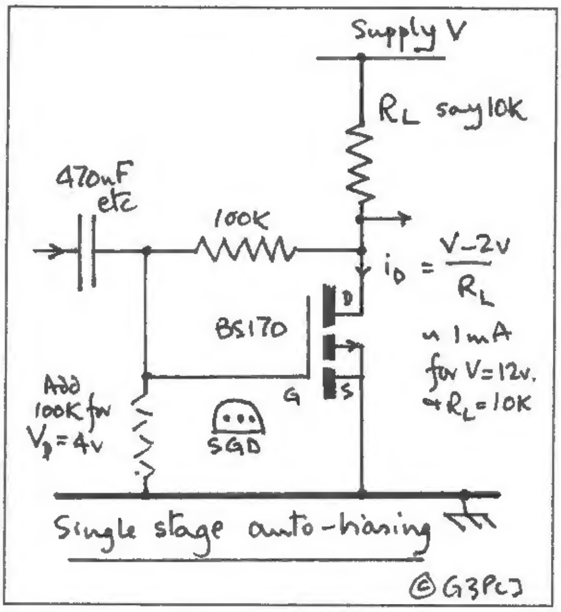
Initial trials have proved that expensive (and rare) variable capacitors are not necessary – permeability tuning is easy, repeatable and easily constructed without special tools or equipment. The anode coil tuner is self explanatory, the grid coil tuner is made by epoxy bonding a 40mm x 40mm x 20mm softwood block to the back of the front panel, and epoxy bonding the coil former to the block. A 7.5mm hole is drilled through, then the front panel and block are drilled 6mm deep with an 8mm drill to make a starter hole for the 8mm brass bolt. The bolt is lubricated with washing up liquid, and gently screwed into the 7.5mm through hole, using the 8mm starter hole as guide. This is done slowly, to avoid splitting the softwood block. This makes a smooth thread, which gives a micrometer action for the tuning. Initial trials using an ICOM 705 receiver show that the output frequency remained within 80Hz (after a 10 minute warm up, and the coil assembly enclosed in a simple pcb material earthed box) for over an hour. This is entirely acceptable for a one valve transmitter, with home-made tuning components!



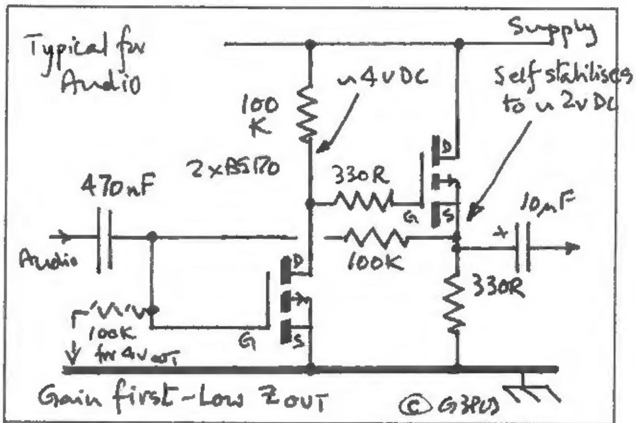
MOSFETs and biasing

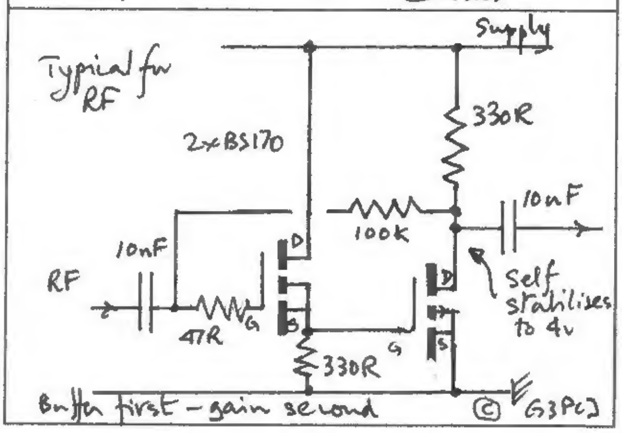
Those of you who have built my kits will know I am very fond of the small BS170 MSOFET. They cost pennies, can stand a drain voltage of up to 60v, max I_d of 800 mA (pulsed), dissipate up to 300 mW without a heatsink, have a R_{DSon} of less than 1.5R typically, forward transconductance of 320 mS, with potentially very high bandwidth (Ton/off of 10 nS) if you can overcome their gate to source capacitance which is typically 40 pF. They typically need about 2 to 2.5v of gate to source positive bias voltage to turn them on, which is what makes them so easy to self bias usefully! They are very versatile devices.

The gate bias current required is effectively zero with it looking like a capacitor, hence very high value resistors can be used to feed the desired voltage to the gate to make it conduct. The simplest arrangement for a single device is to connect the gate via say 100K to the drain and it will self bias with a drain voltage of near 2 volts; this leads to a drain (and source) current determined by the supply voltage less the 2v of bias, divided by the drain load resistor. For high gain, high output impedance audio applications the drain load can also be up to 100K. With this bias arrangement, the drain can only swing negative by 2 volts (but much more positive) so the peak to peak output voltage for most analogue signals cannot exceed 4 volts p-p. If more output is needed, then a gate bias divider can be used – 2 x 100K sets the drain volts at about 4v so it gives 8v p-p max output. A typical circuit is shown right.



The next stage of complexity is to add a source follower buffer stage and arrange that the two are self biasing by connecting them together in a DC feedback loop rather like the arrangements used for op-amps. The extra stage can be placed before or after the main voltage gain stage depending on whether high input impedance is desired or whether you need to get the output impedance down. See right. Placing the buffer first has most use in RF circuits where the high gate capacitance of the gain stage would be a problem without the buffer; in low frequency circuits as described in the first box, that capacitance is not a problem. Gain first/buffer second, and hence low output impedance, is a good speech amp scheme and both stages can be made to voltage amplify as in the High Ham – see earlier note in this issue.

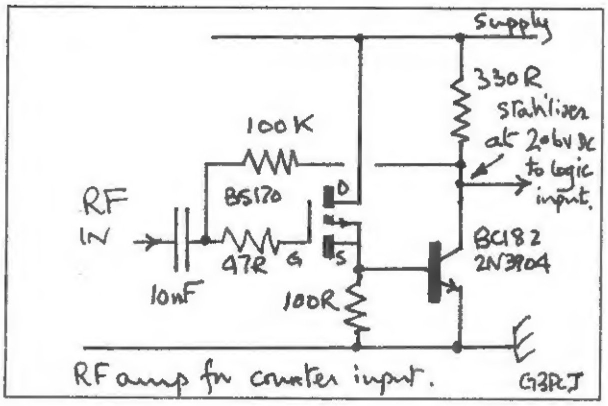




Continued over.....

MOSFETs and Biasing Contd

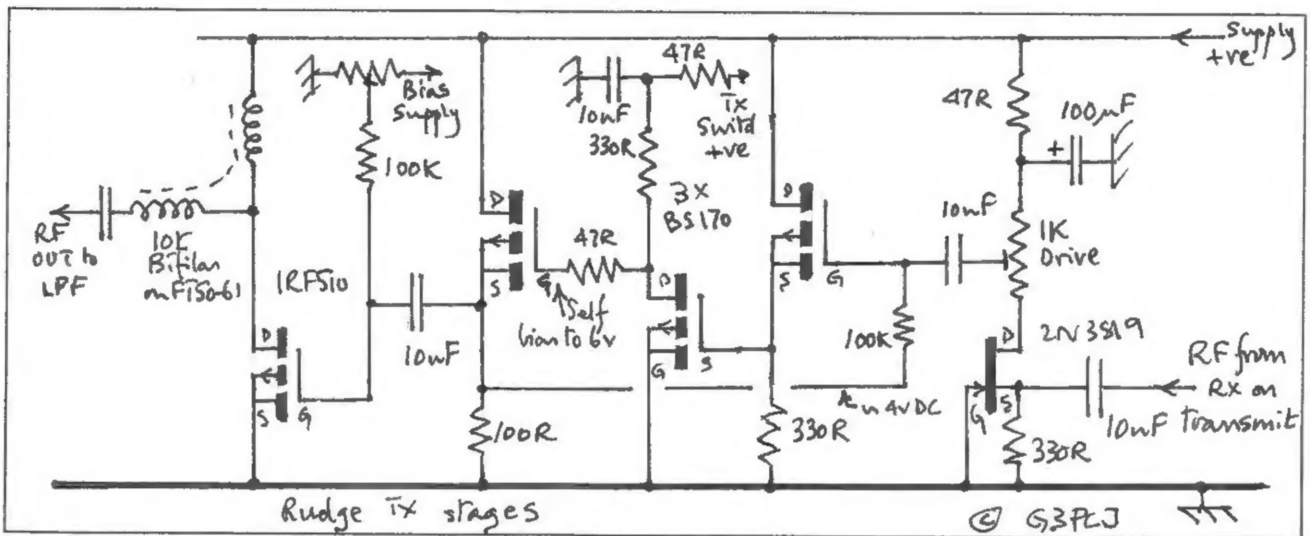
An interesting derivative of this two device circuit is to have one of them as a bipolar device instead of two MOSFETs. This makes their combined bias voltages (2 + 0.6) close to 2.5v which is of course the halfway threshold of digital circuits run on a 5v supply. Hence a pair like this makes a good high frequency amplifier feeding into a digital squarer stage such as is wanted at the input to a digital counter! See right!



RF amp for counter input.

I have failed to explain the presence (in these buffer stage circuits above) of the low value resistors in series with the gates, typically 47R, or more for audio applications! Due to the inherent capacity between gate and source of a MOSFET, any additional capacity from the load across the source to ground turns this circuit into the well known Colpitts oscillator configuration! Given their high gain and high speed, they will oscillate! Years ago I had an audio filter using a source follower that did not work as intended – it was actually oscillating at a few hundred MHz! So if in any doubt, always add a gate stopper resistor to a source follower. The corner frequency of the stopper and gate capacitance must be above max signal frequency.

The final elaboration is to add another source follower so that the three stages together have high input impedance, high gain and low output impedance. This scheme can then work much like an operational amplifier where the circuit gain and response are determined by the feedback elements. This is the scheme used in the Rudge transmitter where the feedback is really only for DC purposes and the gain is the maximum that the gain stage will provide. This can be high, by using a high drain load resistor (eg for audio), provided that the capacity of the following stage does not reduce the bandwidth below that desired. But for RF purposes, much lower drain load resistors are needed. In many of my superhet designs, the RF transmit signals are generated in low level RX stages so that after their RF bandpass filtering, the signal level is about 100 mV p-p with nominal 50R output impedance. This is well suited to feeding into a grounded gate JFET stage (which is self biasing unlike the MOSFET) with a Drive RF gain preset as its drain load. As that has an output impedance is about 1K, the total RF TX amplifier benefits from the third MOSFET buffer stage. With an input of 100 mV p-p, the four devices easily generate 5v p-p for driving the high gate capacity of an IRF510 TX output power stage. G3PCJ



Rudge TX stages

Wall Warts

Wall warts is the American name for the combined plug and power supply that is often supplied to power consumer appliances. These units are often to be seen at low prices at rallies and I expect that many a ham shack has a box full of them! They appear to come in four classes:-

- Switched mode PSU. As I have no experience of this type, it will not be discussed further.
- Cheap & cheerful. These consist of a transformer, rectifier and capacitor.
- Sophisticated. These are similar to the cheap and cheerful but they also include a three terminal regulator and maybe marked as being regulated.
- Fake. These are labelled as being regulated but are in fact cheap and cheerful. IF you open them up, they contain a PCB to take a regulator which has not actually been fitted. They maybe production rejects or a variety that has not gone through approval and is hence fraudulently marketed.

All of the above can be used in the ham shack. The first thing to do is to check the polarity of the output plug – most have the inner as the positive but not all. You need also to obtain the correct socket as there are many different diameters.

An easy way to check whether the output is regulated is to measure the off-load output voltage. If it is about 40% higher than what is claimed, then it is not regulated. If you have a scope, it is also worth looking at the output smoothing especially when loaded to the rated output. Anything with more than 20 mV or so of ripple at 50 or 100 Hz is probably un-regulated.

Now let us look at some uses. Some of my test gear requires 5 volts and this is provided by a three terminal regulator unit within the test gear. These can be powered by any of the above wall warts provided their voltage is high enough. The usual 5 volt regulator needs a minimum input of 7 volts and can withstand up to 20 volts or more depending on load current and hence power to be dissipated. If the wall wart provides the desired voltage, adequate current, and appropriate regulation then it can be used without any further ado. I happily run a communications receiver in such a way but a couple of extra capacitors were needed across the supply to reduce noise on the supply line.

Another thing that must be considered is the current that you wish to draw. I have no idea how these units are rated; for continuous or intermittent use? In practice this has not been a problem for me as none of my test equipment has needed anything approaching the rated current. As a guide line, I derate them by about 50% but the judgement is yours. Perhaps a reader may be able to comment.

Some wall warts look as though they could easily power a QRP station. Ultimately, how you use them is limited by your imagination.

Supplies for nominal 12v gear

Much amateur radio equipment runs off nominal 12v DC supplies but what does this mean? Many would say that the gear expects 13.8v which is the normal float charge voltage of a lead acid battery. Beware that car 12v systems can often range from below 10 to nearer 18v! Most equipment will often work from about 11 volts up to 15v before things go pop but do be careful with unregulated plain transformer, rectifier and large smoothing cap supplies. Their off load voltage can rise by 40% as Gerald mentions above. If the equipment has an internal 12 v regulator it is likely to need an absolute minimum of 14v and about 15v is more practical to allow for lead volt-drop; if derived from an unregulated source that input could rise to 21v!

In kits that need a regulated internal line, I often use 8 volt Low Drop Out (LDO) regulators that require a supply with as little as half a volt above the output. Provide the circuits supplied from the incoming main supply can stand it, the incoming supply range can then include 9 volt batteries up to the higher figures found in cars. But do beware of transients (low and high) when starting the engine! Best turn the radio off first! Do check the polarity too! G3PCJ

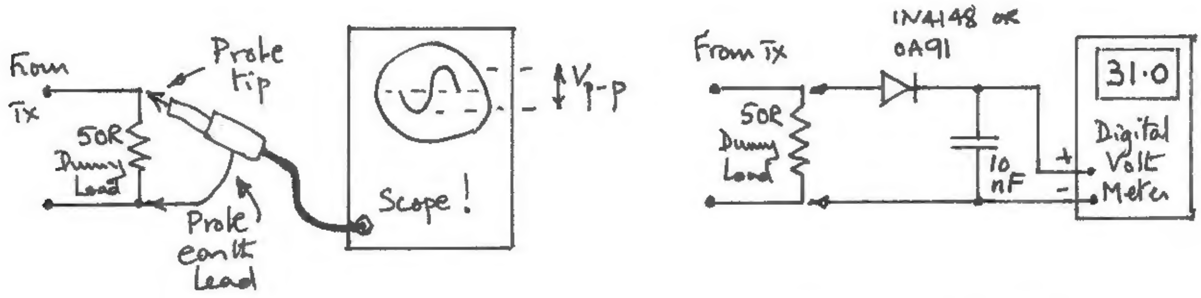
RF Power Measurement by Philip Lock

Many cheaper SWR/Power instruments are not very accurate when measuring low power. Here are two ways of measuring RF power, without the use of a power meter. If you have an Oscilloscope which is accurate at the frequency you wish to measure the power at, then connect the output of your transmitter across a 50 ohm resistor, and also the Y input of the scope – see below. The peak to peak voltage is read and then converted to RMS by dividing it by 2.828. Then multiplying it by itself, and then dividing it by the value of the load resistor.

Example - if the peak to peak reading on the scope is 63.2 volts. Then 63.2 divided by 2.828 = 22.348 times itself = 499.433 divided by 50 = 9.988, which is the power in watts.

If you don't have a scope, it can be done with a diode, 10 nF cap and a DVM or sensitive voltmeter. See circuit below. This measures the peak voltage to which must be added the voltage drop in the diode, and then converted to RMS by dividing it by 1.414. Then multiply by itself, and divide by the value of the load resistor.

Example - if the voltage reading on the DVM is 31.0 volts plus 0.6 volts for the drop in the diode if it is a silicon diode like a 1N4148 , or 0.3 volts if it Germanium diode like a OA91. Then 31.6 divided by 1.414 = 22.348 times itself = 499.433 divided by 50 = 9.988, which is the power in watts.



Power Measurement with scope or with Digital Voltmeter

©Philip Lock

Storage Batteries

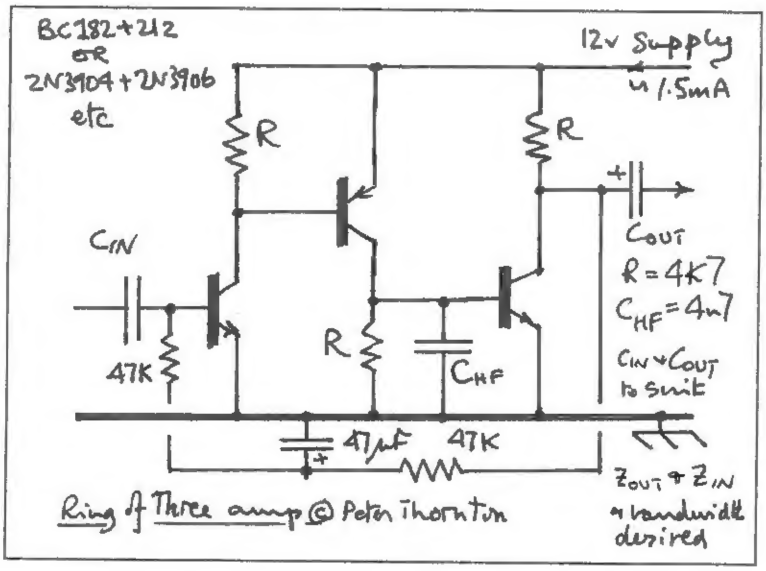
I read that a firm is developing a battery and inverter that will store the energy from a typical 100W solar PV panel of about 1.5 sq m during the day for off grid applications. The inverter has a power rating of about 4 kW (at 240v nominal) so that it could power the vast majority of domestic loads likely to be found in remoter situations. Is this a solar panel plus controller, large 12v battery and big ordinary static inverter? Useful piece of kit!

A second note points out the huge variations in solar PV generated electricity that the national grid has to cope with during the day, almost going from zero to a few hundred MW and back again in minutes! A team from Sheffield University is trialling a very large Lithium battery with bi-directional inverter/charger connected to the grid. Power handling ability is 2 MW, the battery is 800v with a storage capacity of about 15 MWHr & they are connected to the local 11 kV network. They intend to explore how these might operate at the sub-station level to even out grid demand which cannot be easily met from fossil fuel & nuclear generators that cannot be ramped up/down quickly. The alternative of pumped water storage needs much space! G3PCJ

Ring of three amp By Peter Thornton.

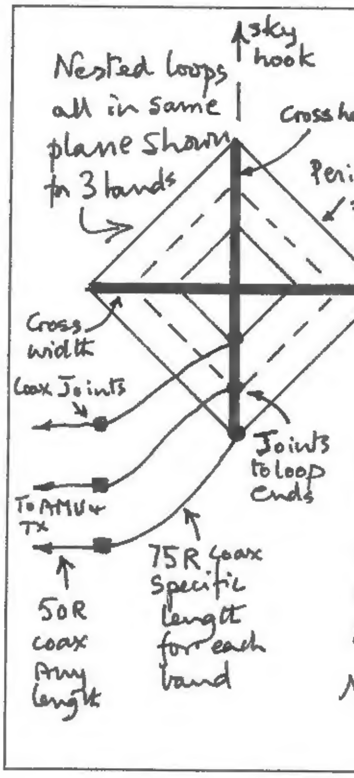
Much is made nowadays about the easy biasing power that MOSFETs allow: but complementary bipolar transistors can offer substantially simpler circuits if complementary devices are used. The direct coupling produces high gain, dc stability with minimal current consumption and low component count. Try that with MOSFETs....! Here is an amplifier which is very high gain (90dB), can run from 6 - 24v dc supply and is unconditionally dc stable. It consumes 1.5mA from a 12v supply with components as shown, and can use virtually any silicon bipolar complementary devices, but I'd recommend low noise audio types as the gain is so high. The gain can be engineered to any value required by adding an input feed in resistor, the gain then being the two 47k feedback resistors divided by the feed on resistor – as per normal op-amp and twin transistor buffer amplifiers.

Practical uses include the audio section of direct conversion receivers, the audio amplifier for a true TRF receiver and many other applications. You can engineer the frequency response easily with input capacitor and the third transistor's base to ground shunt capacitor; or devise (like op-amp filters) various networks to go in the feedback path. With the values shown, the amplifier will have a bandwidth of roughly 20Hz to 20kHz (depending on source and load impedances).



Nested Loop Antennas

Charles Wilson sends along a ARRL note by N3FJP about nested multi-band rectangular loop antennas mounted on a single rotatable pole. Each has its own 50R any length feed line which connects to a 75R matching section just before the loop, so that band selection is done in the shack. If you make it for all five bands (have as many as you wish), it is large & the windage forces will be large so a stout frame is required – that is the hard bit! Ideally you hang it from some suitable sky-hook! G3PCJ



Based on:-
$\text{Perimeter} = \frac{1005}{f_{MHz}}$ ft

Match 75R has 0.66 vel factor.
$L = 246 \times V/f_{MHz}$ ft.

Band	Perimeter - ft	Side - ft	Cross height + width - ft	75R Match Length - ft
20m	70.90	17.72	24.81	11.45
17m	55.47	13.87	19.41	8.96
15m	47.35	11.84	16.57	7.65
12m	40.30	10.07	14.10	6.51
10m	35.26	8.82	12.34	5.70

Nested Loop Antennas sizes after N3FJP